



wherein  $Q^1$  represents a bonding group that crosslinks the two conjugated five-membered cyclic ligands  $(C_5H_{5-a-b}R^8_b)$  and  $(C_5H_{5-a-c}R^9_c)$ ;  $Q^2$  represents a bonding group that crosslinks the conjugated five-membered cyclic ligand  $(C_5H_{5-a-d}R^{10}_d)$  and the group  $Z^1$ ;  $R^8$ ,  $R^9$ ,  $R^{10}$  and  $R^{11}$  each represent a hydrocarbon group, a halogen atom, an alkoxy group, a silicon-containing hydrocarbon group, a phosphorus-containing hydrocarbon group, a nitrogen-containing hydrocarbon group, or a boron-containing hydrocarbon group; and a plurality of these groups, if any, may be the same or different, and may be bonded to each other to form a cyclic structure; a represents 0, 1 or 2; b, c and d each represent an integer of from 0 to 5 when a = 0, or an integer of from 0 to 4 when a = 1, or an integer of from 0 to 3 when a = 2; e is an integer of from 0 to 5;  $M^1$  represents a transition metal of Groups 4 to 6 of the Periodic Table;  $M^2$  represents a transition metal of Groups 8 to 10 of the Periodic Table;  $L^1$  and  $L^2$  each represent a coordination-bonding ligand;  $X^1$ ,  $Y^1$ ,  $Z^1$ ,  $W^1$  and  $U^1$  each represent a covalent-bonding or ionic-bonding ligand; and  $L^1$ ,  $L^2$ ,  $X^1$ ,  $Y^1$ ,  $Z^1$ ,  $W^1$  and  $U^1$  may be bonded to each other to form a cyclic structure.

Specific examples of  $Q^1$  and  $Q^2$  in formulae (2) and (3) include (1) an alkylene group having from 1 to 4 carbon atoms, or a cycloalkylene group, or the group substituted by a lower alkyl or phenyl group at its side chain, such as a methylene group, an ethylene group, an isopropylene group, a methylphenylmethylene group, a diphenylmethylene group, a cyclohexylene group, etc.; (2) a silylene group, or an oligosilylene group, or the group substituted by a lower alkyl or phenyl group at its side chain, such as a silylene group, a dimethylsilylene group, a methylphenylsilylene group, a diphenylsilylene group, a disilylene group, a tetramethyldisilylene group, etc.; and (3) a hydrocarbon group (e.g., a lower alkyl group, a phenyl group, a hydrocarbyloxy group (preferably, a lower alkoxy group), etc.) containing germanium, phosphorus, nitrogen, boron or aluminium, such as a  $(CH_3)_2Ge$  group, a  $(C_6H_5)_2Ge$  group, a  $(CH_3)P$  group, a  $(C_6H_5)P$  group, a  $(C_4H_9)N$  group, a  $(C_6H_5)N$  group, a  $(CH_3)B$  group, a  $(C_4H_9)B$  group, a  $(C_6H_5)B$  group, a  $(C_6H_5)Al$  group, a  $(CH_3O)Al$  group, etc. Of those, preferred are alkylene groups and silylene groups.

$(C_5H_5-a-bR^8_b)$ ,  $(C_5H_5-a-cR^9_c)$  and  $(C_5H_5-a-dR^{10}_d)$  are conjugated, 5-membered cyclic ligands, in which  $R^8$ ,  $R^9$  and  $R^{10}$  each represent a hydrocarbon group, a halogen atom, an alkoxy group, a silicon-containing hydrocarbon group, a phosphorus-containing hydrocarbon group, a nitrogen-

containing hydrocarbon group, or a boron-containing hydrocarbon group; a represents 0, 1 or 2; and b, c and d each represent an integer of from 0 to 5 when a = 0, or an integer of from 0 to 4 when a = 1, or an integer of from 0 to 3 when a = 2. The hydrocarbon group preferably has from 1 to 20 carbon atoms, more preferably from 1 to 12 carbon atoms. The hydrocarbon group may be a monovalent one that bonds to the cyclopentadienyl group of a conjugated, 5-membered cyclic group. Two of plural hydrocarbon groups, if any, may be bonded to each other to form a cyclic structure along with a part of the cyclopentadienyl group. Specific examples of those conjugated, 5-membered cyclic ligands are substituted or unsubstituted cyclopentadienyl groups, indenyl groups and fluorenyl groups. The halogen atom includes chlorine, bromine, iodine and fluorine atoms. The alkoxy group preferably has from 1 to 12 carbon atoms. The silicon-containing hydrocarbon group includes, for example, groups of  $-\text{Si}(\text{R}^{12})(\text{R}^{13})(\text{R}^{14})$ , in which  $\text{R}^{12}$ ,  $\text{R}^{13}$  and  $\text{R}^{14}$  each represent a hydrocarbon group having from 1 to 24 carbon atoms. As the phosphorus-containing hydrocarbon group, the nitrogen-containing hydrocarbon group and the boron-containing hydrocarbon group, for example, mentioned are groups of  $-\text{P}(\text{R}^{15})(\text{R}^{16})$ ,  $-\text{N}(\text{R}^{15})(\text{R}^{16})$ , and  $-\text{B}(\text{R}^{15})(\text{R}^{16})$ , respectively, in which  $\text{R}^{15}$  and  $\text{R}^{16}$  each represent a hydrocarbon group having from 1 to 18 carbon atoms. Plural  $\text{R}^8$ 's,  $\text{R}^9$ 's and  $\text{R}^{10}$ 's, if any, may be the same or different ones,